Introduction to Artificial Intelligence

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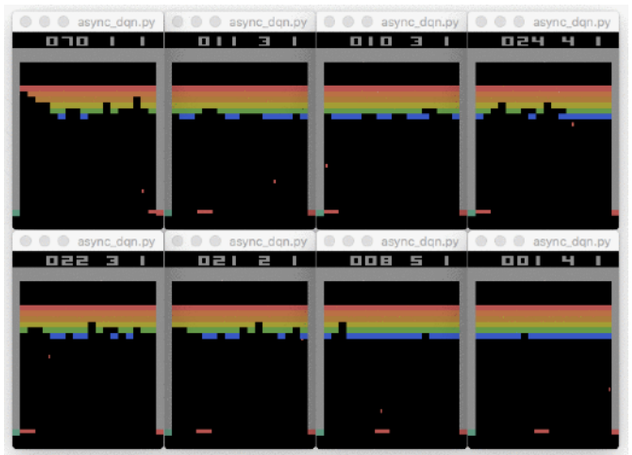
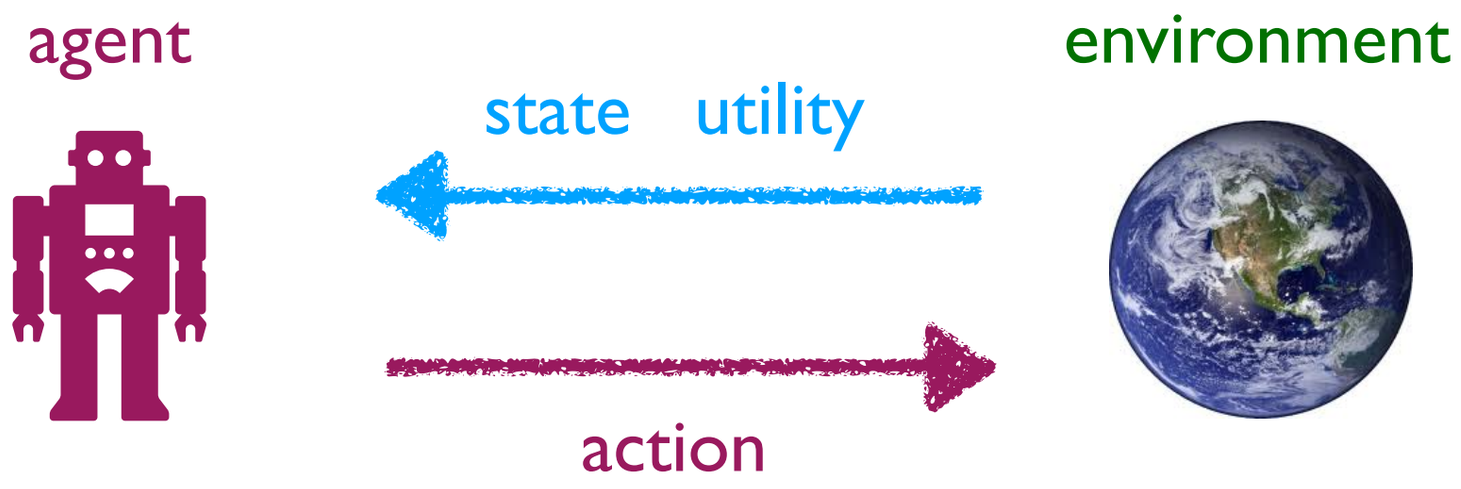
浙江大学

Fall & Winter 2022
Week 9

Decision Making

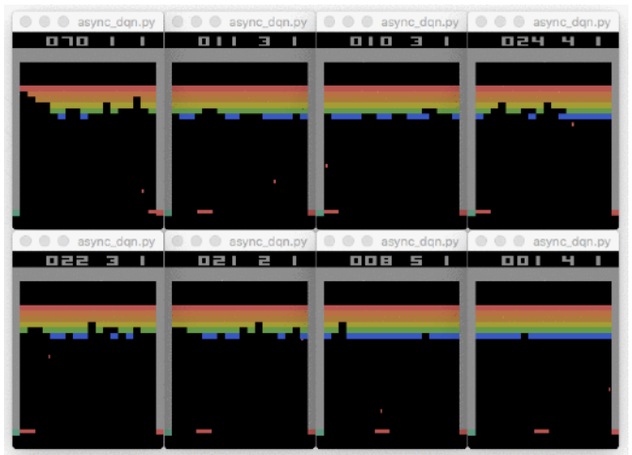


- Conduct action in any state of an environment.



In most problems, the agent needs to do a sequence of actions w.r.t. a sequence of states.

Decision Making



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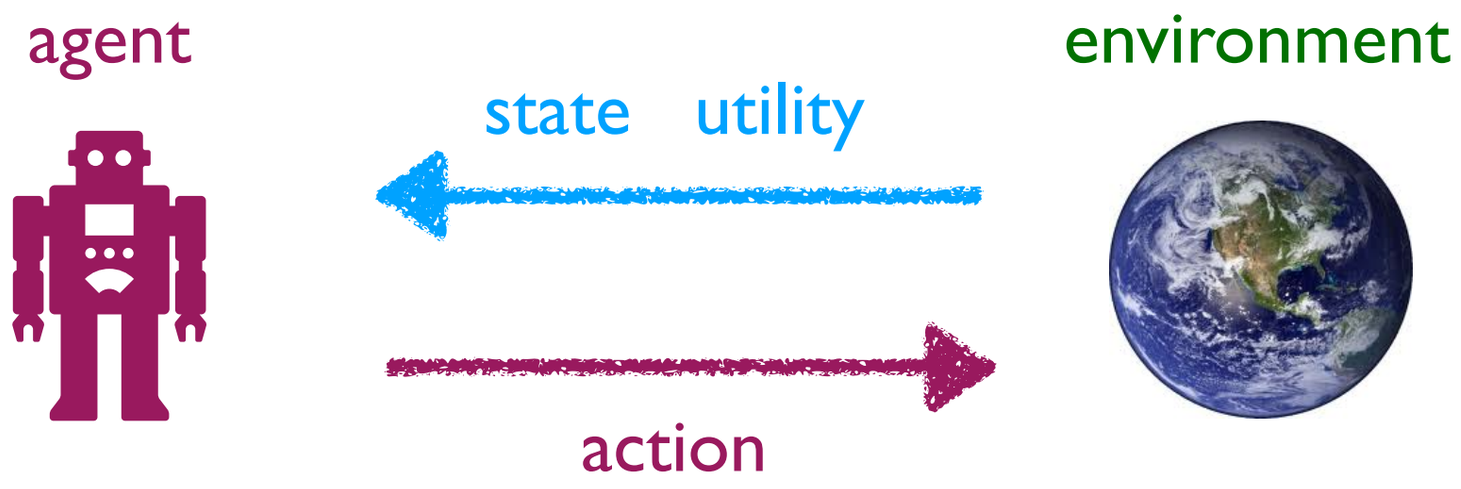
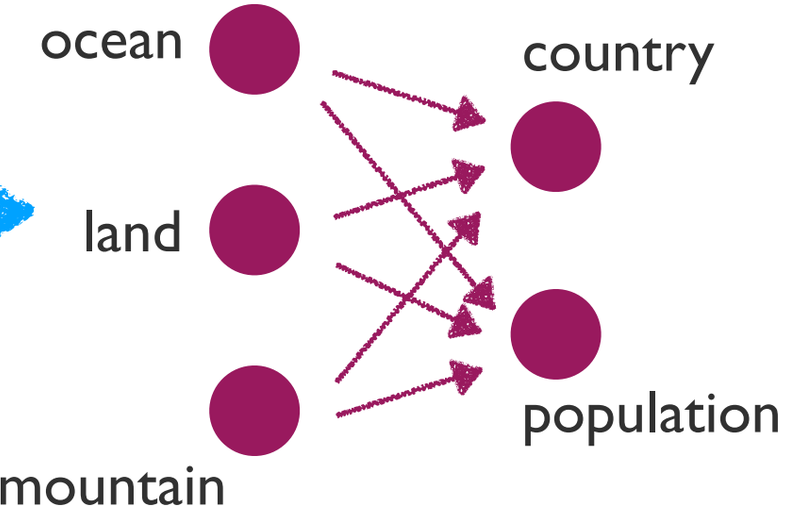


In most problems, the agent needs to do a sequence of actions w.r.t. a sequence of states.

Knowledge in AI Systems

longitude and latitude

ocean, land, mountain



- Turn primitive external states into meaningful internal states.
- Reason about most useful states for decision making.
- Capture internal relationships among factors of decision making.

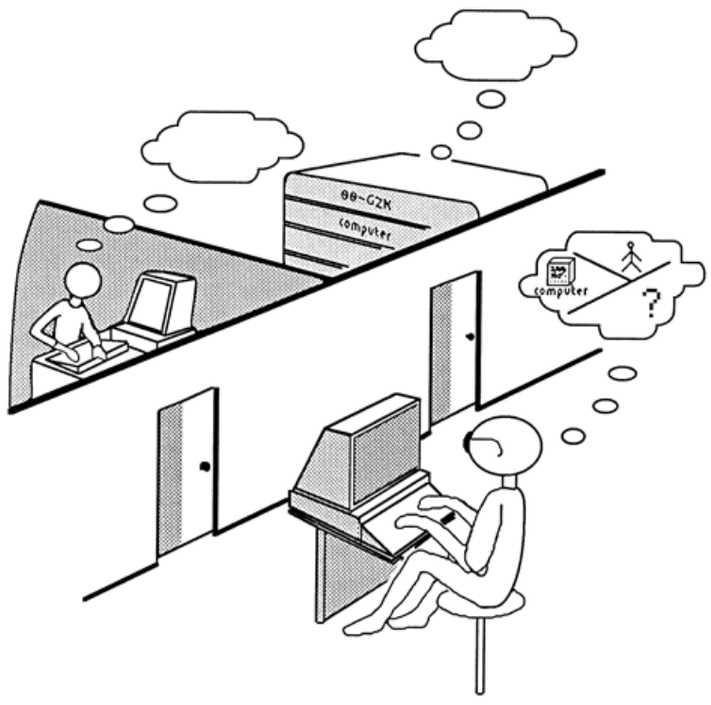
These reasoning rules are called knowledges in an AI system.

Turing Test

"The new form of game can be described in terms of a game which we call the 'imitation game' ".

"Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child's?

— Alan Turing, "Computing Machinery and Intelligence", 1950.



Machine Learning: A Prelude

Machine Learning

In machine learning, we want to obtain these programs (functions) by learning from experience instead of programming by hand.

Computer Program

Input	Output
numbers	sorts
graph	shortest path
random seed	pseudo-random numbers
items: {weight, value}	knapsack solution
images	classes
game	actions to play

Machine Learning

numbers
graph
random seed
items: {weight, value}
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sorts
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- Do all computer programs need to be obtained by machine learning?

Machine Learning

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- Do all computer programs need to be obtained by machine learning?
  - When learning is hard but programming-by-hand is easy: NO!

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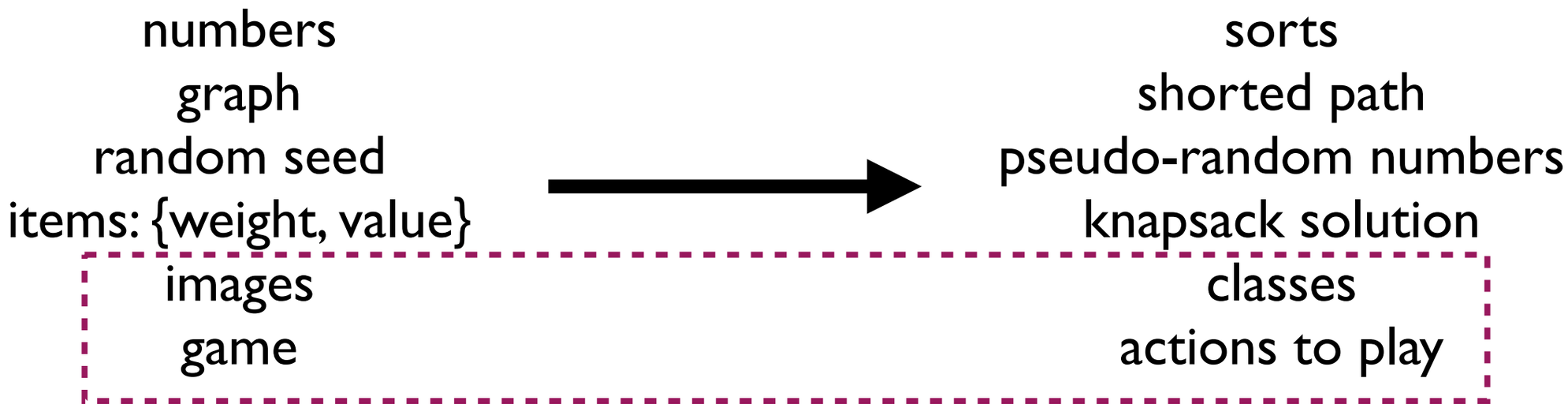
  - When programming-by-hand is hard but learning is easy: YES!

Machine Learning



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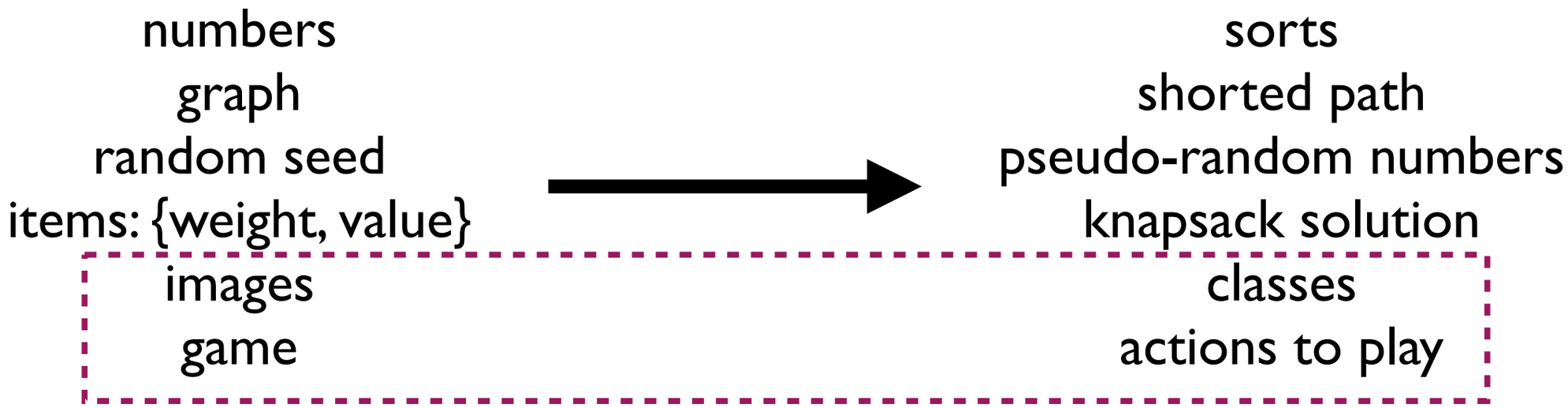
Machine Learning



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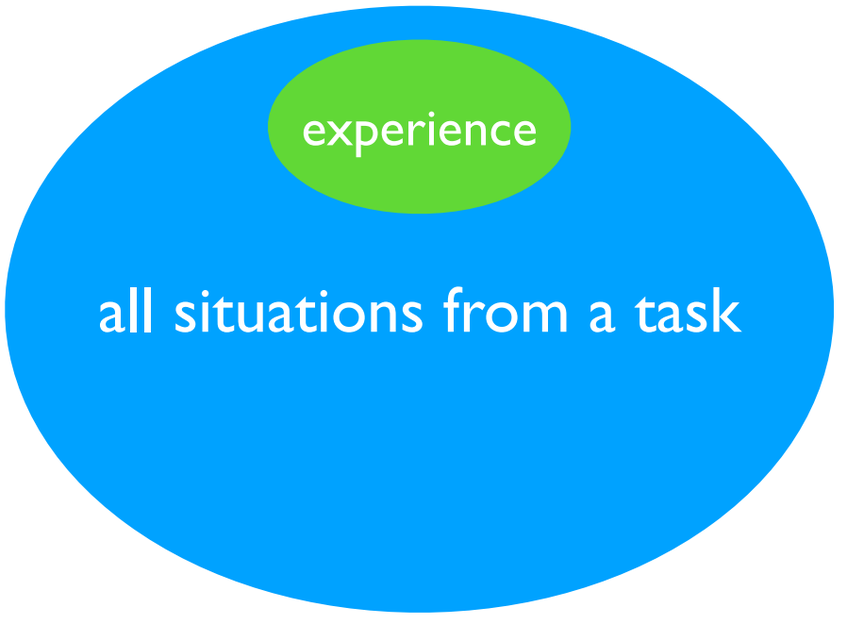
  - When learning is hard but programming-by-hand is easy: NO!
  - When programming-by-hand is hard but learning is easy: YES!

When will learning be possible?
When learning is possible, how to learn efficiently?
Similar to fundamental problems of computation.
What's the difference?

Basic Mechanism



Basic Mechanism

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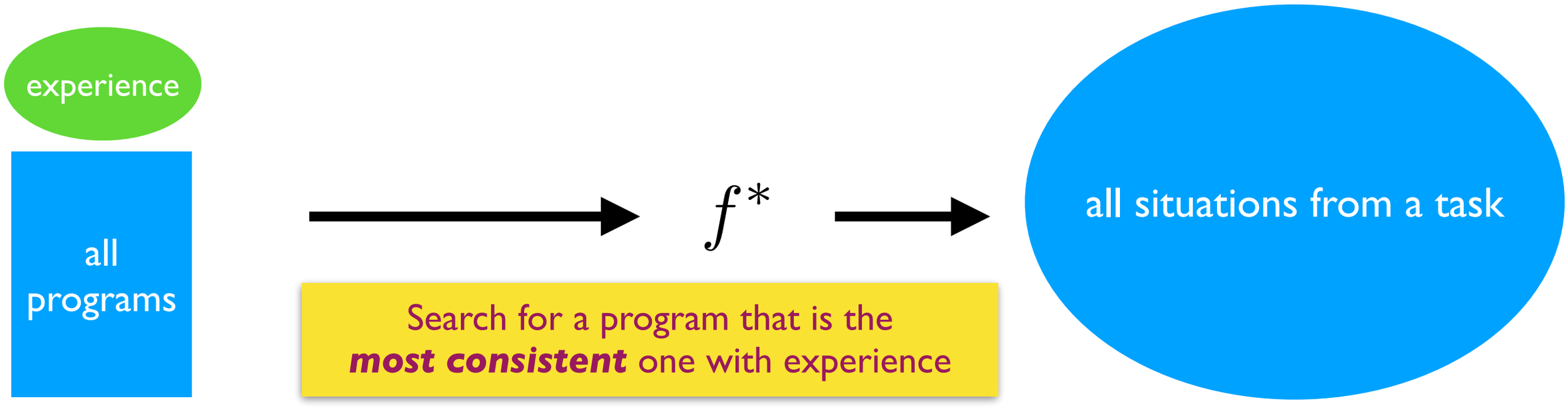
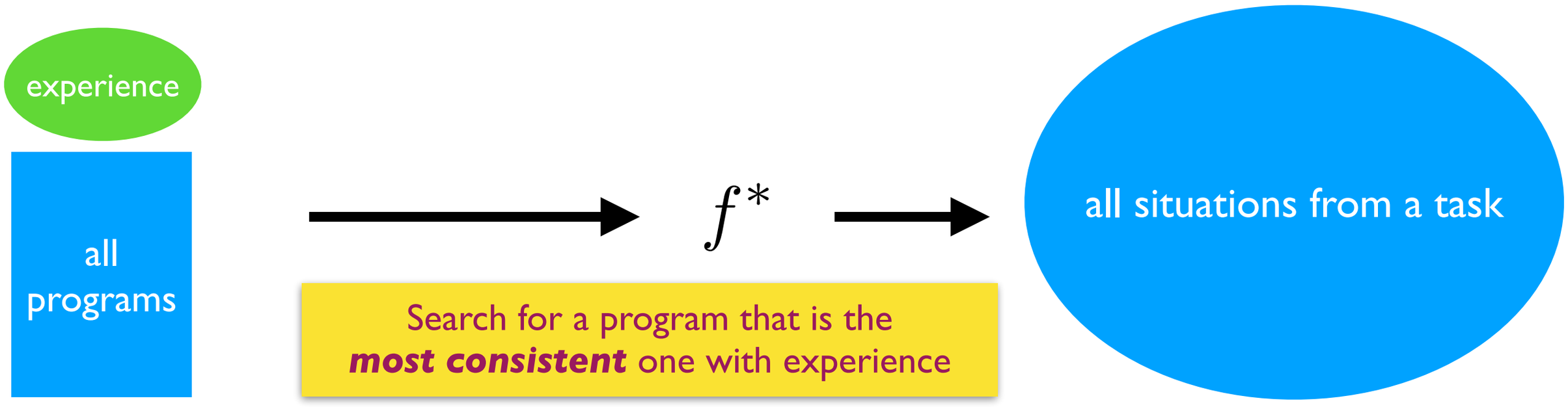
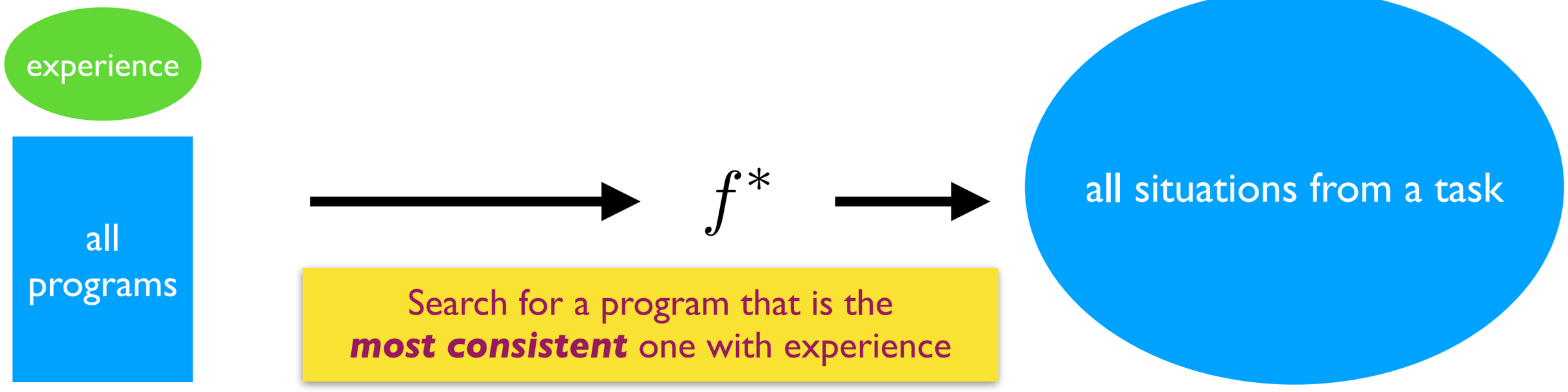


Basic Mechanism



- When will learning be possible and easy?
  - When limited experience can represent all situations.
  - When searching for the best program can be done efficiently.

Machine Learning is a Statistical Problem



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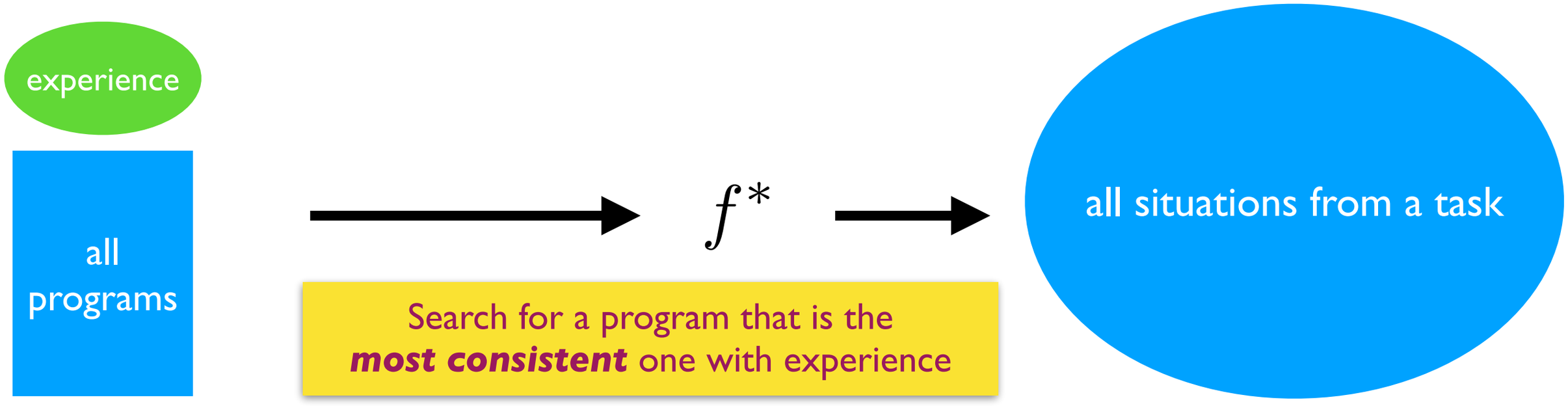

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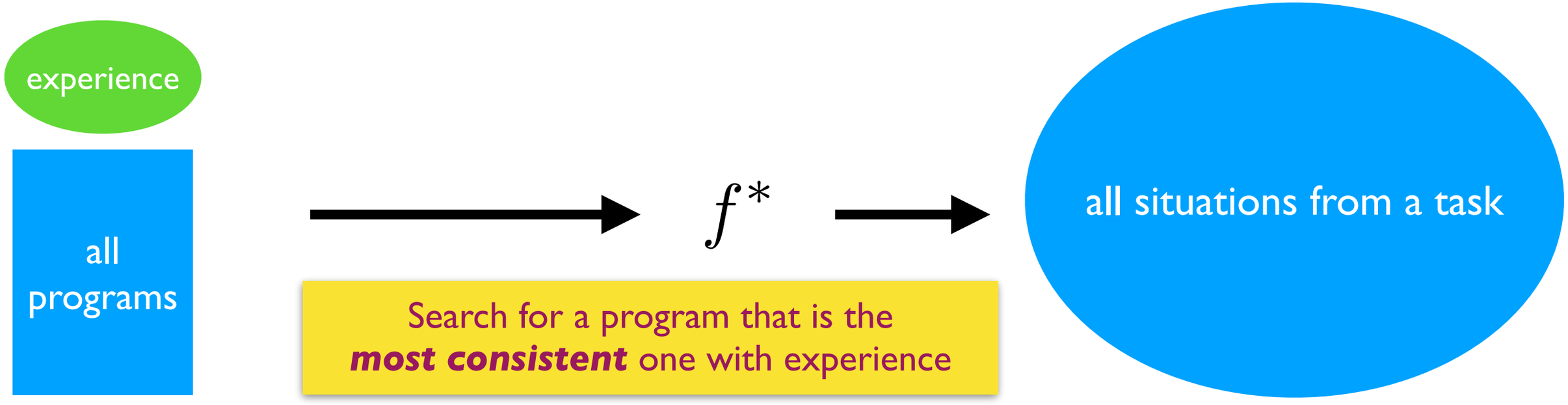
Obtain general rule from limited experiences: **statistics**.
Basic principle: the law of large numbers.

Machine Learning is a Computation Problem



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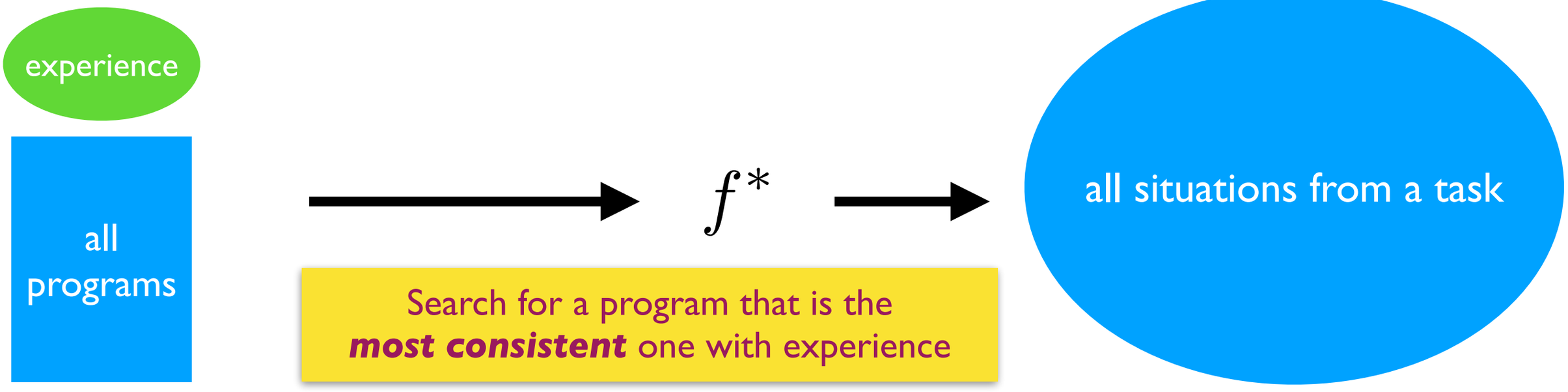

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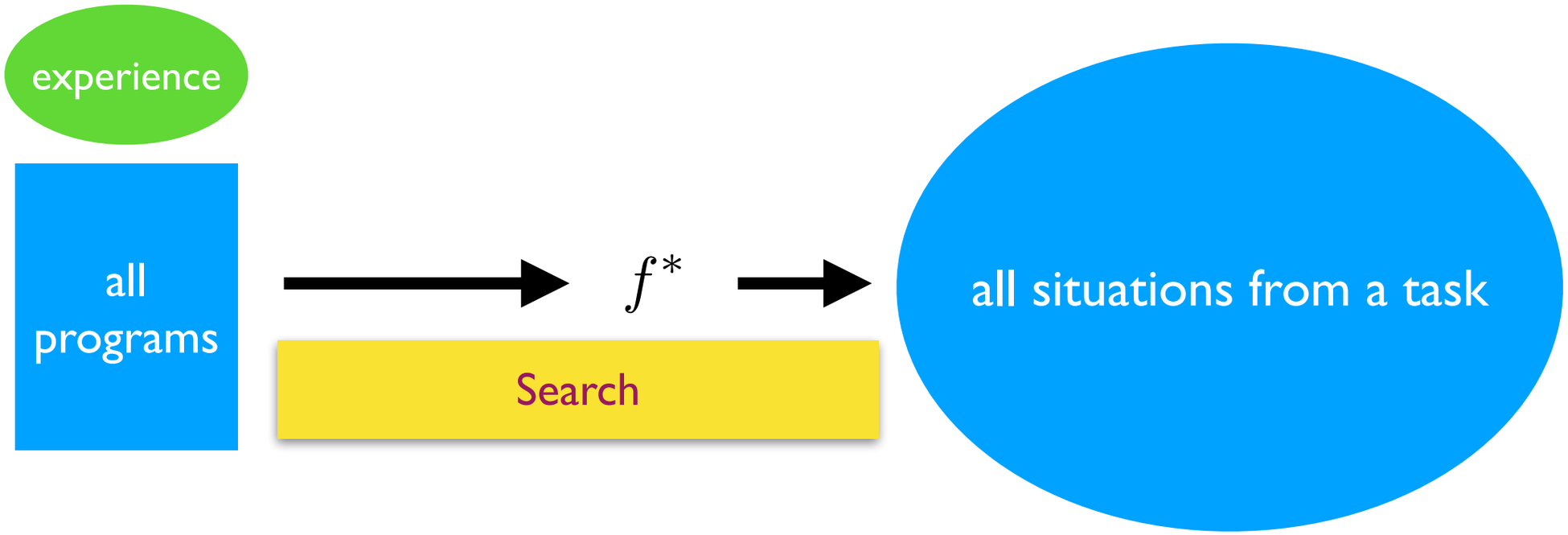
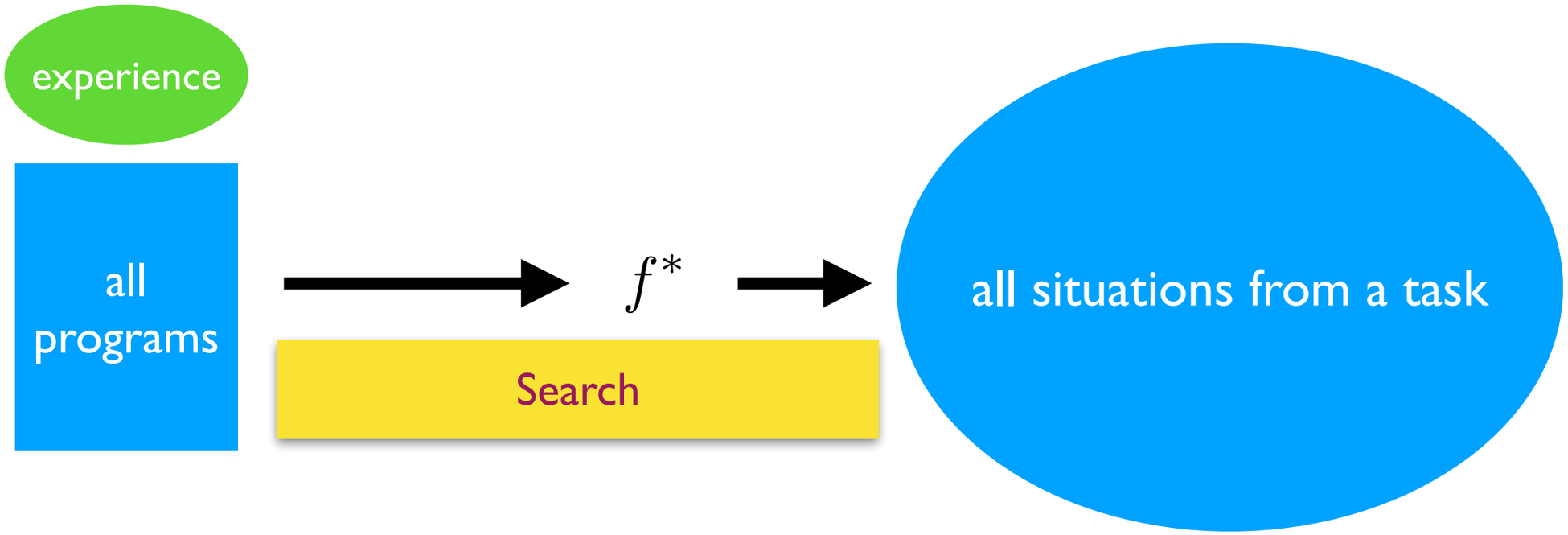
Searching from the optimal solution: **Optimization**.
Optimization is a computation problem.

Inductive Bias in Machine Learning



- Learning is both statistical and computational.
  - We care about both statistical and computational complexity.

Inductive Bias in Machine Learning



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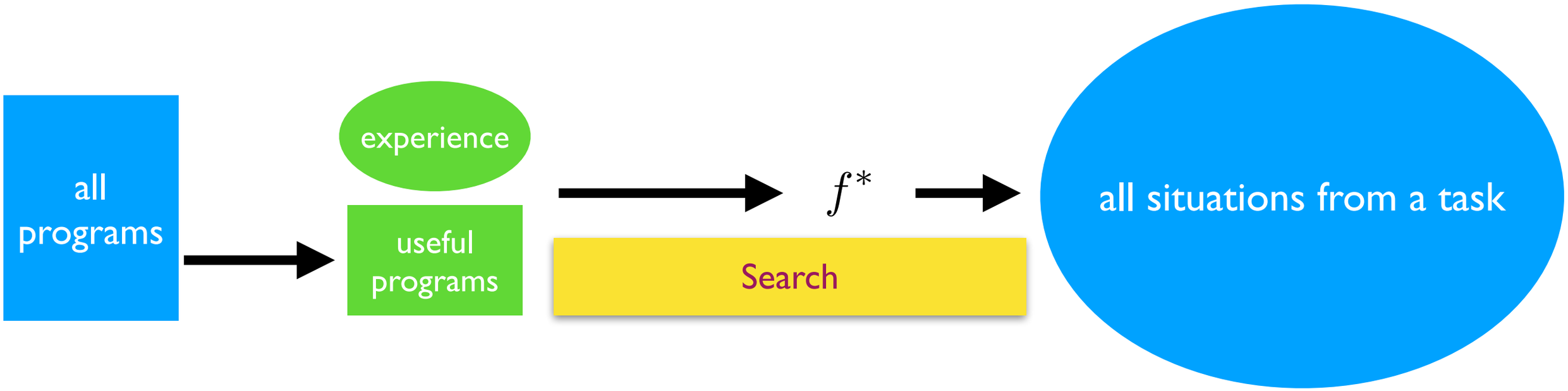
  - Humans can learn from very few experiences and very fast. Why?

Inductive Bias in Machine Learning



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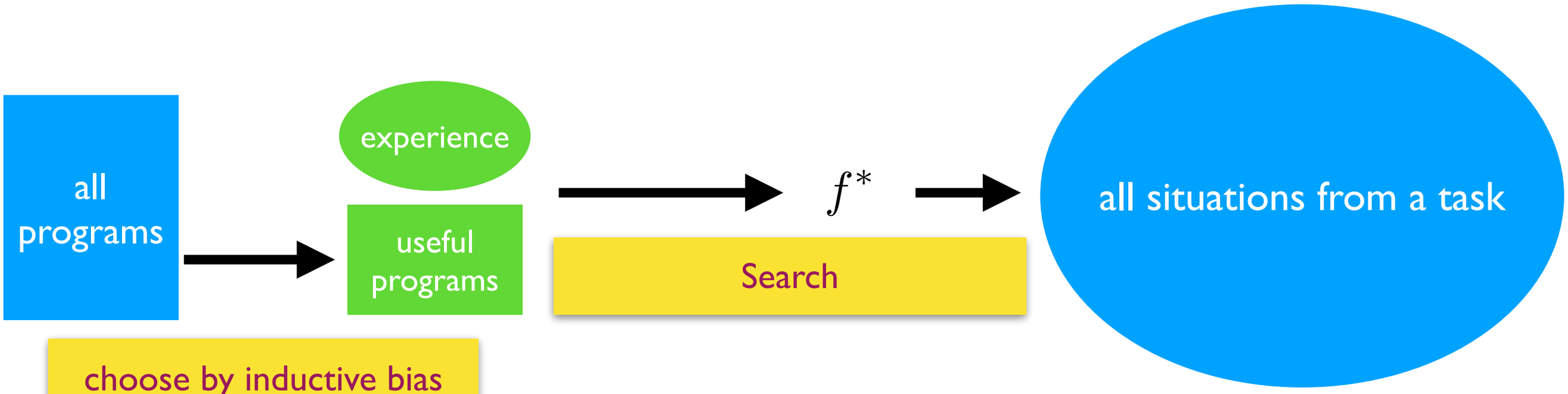

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Not all programs are born equal.
Humans choose the right **inductive bias** to reduce the program set.

Machine Learning: Theory, Algorithm, and Application

- Machine Learning Theory:
  - Understanding the foundations: when will learning be easy?

theoretical computer science, statistics, game theory, information theory…

- Machine Learning Algorithm:
  - Design models and algorithms for *general* machine learning problems.
- Machine Learning Application:
  - Design inductive bias for different applications, e.g. CV, NLP.

Machine Learning Scenarios

- Supervised learning
  - Classification
  - Regression
  - Ranking
- Unsupervised learning
  - Clustering, density estimation
  - Generative modeling
- Semi-supervised learning
- Reinforcement learning
- …

Machine Learning Scenarios

- Supervised learning
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- Semi-supervised learning

← learn from pre-given data

- Reinforcement learning ← learn from self-generated data
- …

Machine Learning Methods

- Symbolic Learning
- Frequentist statistical learning
  - Support vector machine, kernel method
  - Decision tree, random forest, boosting
- Bayesian statistical learning
  - Graphical models
  - Variational inference and approximate sampling
- Neural networks
  - Deep learning

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No absolute boundaries!

Take-Home Messages

- Machine learning is to search for a program that is the most consistent one with experience: statistics + computation.

- There are two fundamental questions to answer:
  - When will learning be easy?
  - When learning is easy, how to learn efficiently?

- Learning is easy with proper:

Inductive Bias + Experience + Optimization

Recommended Textbooks

Schedules

- We will have six lectures on machine learning
  - Two lectures on statistical learning
    - Nearest neighbor vs. linear classification
    - SVM & voting classifiers
  - Two lectures on neural networks and deep learning
    - logistic regression, perceptron, multi-layer neural networks
    - Deep learning
  - One lecture on generative deep models: autoencoder & GAN
  - One lecture on (more advanced) reinforcement learning

Thanks for your attention!
Discussions?